The document was prepared under a contract with the Office of Technology Assessment, Congress of the United States, for the assessment on Basic Research for the 1990s. The conclusions are those of the authors. The document does not necessarily reflect the analytical findings of the OTA, the Advisory Group, or the Technology Assessment Board.

Researcher Perspectives on the Federal Research System

Political Economy Research Institute
McLean, Virginia

Prepared under contract to the Office of Technology Assessment
July 1990

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RESEARCHER PERSPECTIVES ON THE FEDERAL RESEARCH SYSTEM

FINAL REPORT

Prepared

by

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McLean, Virginia

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RESEARCHER PERSPECTIVES ON THE FEDERAL RESEARCH SYSTEM

Introduction

Two surveys, each of 10,000 scientists and engineers, have been conducted by Sigma Xi, The Scientific Research Society. The Society is an honorary organization to which individuals are elected on the basis of their scientific research. In 1986 Sigma Xi inaugurated a biennial Survey of Scientists and Engineers, utilizing its active membership roll of approximately 110,000 as the universe from which a random sample population of about 10,000 was drawn. This population received the survey instrument and a cover letter from the Society urging their response. More than 4100 responded. There were no subsequent requests of the sample. In 1988, when this procedure was repeated, a slightly smaller sample resulted (due to a small decline in membership), and just under 3800 responded to a substantially enlarged survey instrument. Once again, there was no attempt to induce a greater return, however, a telephone operated post survey validation effort indicated no bias in the respondent population.

The field of science designation of the respondent population in both surveys was virtually identical to that of the Society membership (known from codes on the membership roll). In 1988 the attribute of field of science of the respondents was compared to the membership roll and to corresponding nationally

2

published data. This information is displayed in Exhibit 1, and indicates that the respondent population mirrors the membership distribution, and that there exists a close correspondence of both (with the substantial exception of the Social Sciences, which are under represented in the membership of the Society, and a less dramatic under representation of biological scientists) to the universe of U.S. scientists and engineers who possess Ph.D.s and who are employed.[1]

Approximately one-half of the respondents are in academe, one-third in business, and one-sixth in government. The Sigma Xi surveys may justifiably be said to be representative of a broad, interdisciplinary and intersectoral cross section of research scientists and engineers geographically distributed throughout the United States, and their responses to the survey instruments are indicative of the sentiments of this group of individuals. Without overstating claims for the surveys, in many respects the Sigma Xi surveys have given voice to the grass roots of the scientific and engineering research community, thereby creating a substantial source of information to enrich the public policy debate.[2],[3] In particular, two questions, one concerning priority setting in science funding, and the other on the efficacy of peer review, yielded important information for policy makers.[4]

Although the two surveys were not designed to be identical most of the items concerning attributes were the same, and there

were several important questions that appeared in both surveys. (See Exhibits 2-4). This report makes comparisons between the two surveys where that is possible, and offers analysis of other factors where longitudinal comparison is lacking. Accordingly, the report is divided into four sections:

Section One Comparisons Between 1986 and 1988

Comparisons are made between 1986 and 1988 surveys by cross tabular analysis of three attributes, (1) Age, (2) Sector of Employment, and (3) Broad Field of Science arrayed against five queries. The five queries, denoted by their location in the 1988 survey instrument are:

#8 Ranking of most important issues facing science today

26 Ranking of concerns about peer review as an allocation mechanism

22 Whether government research funds are tied too closely to politics

21 Whether Congress should set the "research agenda" for scientists

24 Whether a cabinet level Department of Science and Technology would be valuable

This results in tables which are presented in the Appendix to the Analytical Plan, submitted earlier as detailed backup information. Changes of attitude between 1986 and 1988 are noted when significant, and graphic presentation is prepared to illustrate important points.

Section Two Questions Unique to the 1988 Survey

For the 1988 survey alone the attributes (1) Age, (2) Sector of Employment, and (3) Field of Science are cross tabulated with 12 questions:

#6 Whether science transcends national concerns

7 Whether the quality of basic research is related to the ability of a country to compete

23 Whether pork barrel allocation of public funds is bad

25 Ranking the three best uses of public funds for scientific research

29 Whether the funding of basic of research is a mistake

5

because its value cannot be pre-determined

30 Whether taxpayers can require a specific payoff from basic research even though a result cannot be guaranteed in advance

31 Whether government should fund only applied research if the voters want immediate and measurable returns on their investment

32 Whether government should stop funding applied research on the premise that if it is valuable it will attract private support

33 Whether scientists feel they have a responsibility for general improvement in the public understanding of basic research

36 Whether more funding should go to education rather than to research if total funding for science were to remain about the same

37 Whether university requirements to do both research and teaching are detrimental to both research and education

41 Whether a career in science is recommended

The resulting tables are located in the Appendix to the Analytical Plan, however, findings of significant interest are committed to tabular and graphic presentation in the text itself.

Section Three Gender Partitioned 1988 Survey Data

Gender identification occurred in the 1988 Survey for the first time. All questions identified in Section One and Section Two which pertain to the Second Survey of Scientists and Engineers have been examined in terms of differences in opinion related to gender. Any differences of significance are reported here. The effort for this section has also resulted in a number of tables for examination and commentary, and these are found both in the Appendix to the Analytical Plan and in the text.

Section Four Summary Narrative

From analysis of the more than 80 tables described above an interpretive narrative of researcher preferences for and perceptions of Federal involvement with the research system is offered.

Materials here appended are: a table comparing Society membership to the sample and to nationally published data, the survey instruments, and tables of data describing attributes of the respondents.

Throughout the text the survey questions are clearly identified by italic type, and responses are shown as percentages within brackets. A number of the questions are really statements to which responses could be chosen from the following scale: Agree Emphatically; Agree in Substance; No Opinion; Disagree in Substance; Disagree Emphatically. Tables and charts which accompany the text usually display both the full range of responses and a snapshot of the percentage of agreement versus disagreement of those having an opinion on the question.[5]

SECTION ONE

Comparisons Between the 1986 and 1988 Surveys

The Most Important Issues Facing Science

1986 I believe the two most important issues facing the scientific community today are: Interruptions in funding for research (22%) Lack of public understanding of science's place (22%) Over-politicization of research (15%) Lack of interdisciplinary training (14%) Over-reliance on science to provide answers and find solutions (12%) Over-commercialization of research (5%) Other (5%) Fraud and plagiarism in research (3%) Disappearing fields of inquiry (3%)

1988 In the 1986 Survey of Scientists, the four items listed below were regarded as the most important issues facing science. Which issue do you consider to be most important at the current time? Lack of public understanding of science (40%) Over-politicization of research (24%) Interruptions in funding for research (21%) Lack of interdisciplinary training (10%) Other (5%)

In 1986, interruptions in funding for research and lack of public understanding were perceived to be the most important issues for scientists, 30% of whom selected each issue. Interruptions in funding was cited as being of particular

		Important Issues Facing Science				
	Employment Status	Lack of Public Understanding of Science	Interruptions in Funding for Research	Over-Politicization of Research	Lack of Interdisciplinary Training	TOTAL
1986	Acad/Tenured	31.16	35.74	15.82	17.28	100
1988		44.67	26.08	19.25	9.07	100
1986	Acad/Non-ten.	29.93	33.22	19.25	17.61	100
1988		40.09	24.76	21.70	13.44	100
1986	Government	25.89	31.72	22.44	19.96	100
1988		35.44	21.01	32.91	10.63	100
1986	Private	31.06	20.92	25.60	22.42	100
1988		44.31	16.91	26.72	12.06	100
1986	Other	31.81	29.37	18.53	20.28	100
1988		39.18	22.22	29.82	8.77	100
1986	Total	30.14	30.14	20.34	19.39	100
1988		42.30	22.33	24.59	10.79	100

		Important Issues Facing Science				
	Age	Lack of Public Understanding of Science	Interruptions in Funding for Research	Over-Politicization of Research	Lack of Interdisciplinary Training	Total
1986	20-29	29.74	28.10	23.20	18.95	100
1988		42.67	21.98	24.14	11.21	100
1986	30-39	29.82	29.74	19.94	20.50	100
1988		43.12	24.88	21.79	10.20	100
1986	40-49	29.48	31.31	20.65	18.56	100
1988		44.61	22.50	23.95	8.94	100
1986	50-59	29.57	31.72	20.51	18.20	100
1988		39.05	22.36	26.19	12.40	100
1986	>60	31.58	28.13	19.85	20.44	100
1988		41.96	20.11	26.27	11.66	100
1986	Total	30.08	30.15	20.41	19.36	100
1988		42.30	22.33	24.59	10.79	100

importance by most respondents; however, individuals working in the private sector and the youngest and oldest categories of scientists (under 30 and over 60) selected lack of public understanding over this issue. Interruptions in research funding was selected by 22% of the scientists and it ranked third out of the four issues. Results did not vary significantly by age and, in terms of scientific field, biologists and health scientists were somewhat more likely to select this issue (both groups ranking it to be the second most important issue). And as in 1986, those working in the private sector were least apt to consider interruptions in research funding to be important. With regard to lack of public understanding of science, scientists in the private sector, scientists under the age of 30 and over the age of 60, engineers and physical scientists were most apt to select lack of public understanding as an important issue. In 1988, lack of public understanding was selected as the most important issue facing science (42%). It was considered to be especially important by biologists, math and computer scientists and physical scientists. Survey participants working in the government were least likely to deem this issue important.

The issue of over-politization of research was ranked third among these four issues in 1986 (followed closely by lack of interdisciplinary training) and was selected by a fifth of the respondents as being important. Math and computer scientists, the youngest scientists, and those in private practice were somewhat

more likely to consider this issue to be important. However, attitudes changed by 1988, with just over one-quarter of respondents citing over-politization to be a problem of concern. This issue ranked second in 1988. Government workers were more apt to select this issue and biologists and physical scientists were least likely to do so.

As noted previously, lack of interdisciplinary training was ranked fourth in 1986 (although the difference between this issue and that ranked third is statistically insignificant) and was selected by 14% of survey respondents. Private sector scientists, math and computer scientists, and social scientists were most apt to consider this issue to be of import. In 1988, this issue was ranked fourth and was selected by 11% of scientists. This selection did not vary significantly across age groups, employment sector, or by scientific field.

A greater change in attitude concerning the issue of over-politicization of research occurred between 1986 and 1988. This issue was ranked third among the top four issues in 1986 and was selected by 15% as being important. Math and computer scientists and those in private practice were somewhat more likely to consider this issue to be important. However, attitudes changed by 1988 with one-quarter of respondents citing over-politicization to be an issue of concern, elevating it to second place in 1988. Government workers were more apt to select this issue and

biologists and physical scientists were least likely to do so.

Peer Review Issues

1986 Government should monitor and assure the quality of ongoing and completed research by a process of peer review to protect the public's tax monies, health, and safety. Agree Emphatically (32%) Agree in Substance (54%) Neither Agree Nor Disagree (3%) Disagree in Substance (8%) Disagree Emphatically (3%)

The systems required to evaluate research and to guarantee its cost-effectiveness are in place, sufficient, and operating effectively. Agree Emphatically (3%) Agree in Substance (29%) Neither Agree Nor Disagree (22%) Disagree in Substance (34%) Disagree Emphatically (12%)

1988 The greatest concern(s) I have with respect to the use of peer review in the grant awarding process is(are): Reviews are marred by cronyism, old boys networks, and insider politics (32%) Original, non-mainstream ideas are unlikely to be funded (27%) Reviews are perfunctory, cursory, or non-substantive (9%) Not Applicable, I think peer review works well as it is (8%) Reviewers are not expert in applicant's field (8%) Reviews are conflicting (5%) Award decisions are inconsistent with reviews (5%) Original ideas are sometimes "appropriated" or "leaked" by a reviewer or program officer (5%) Other (1%).

With respect to peer review, the surveys did not include questions sufficiently similar to enable direct comparison, indeed, it was because the 1986 Survey revealed dissatisfaction with the process that a more incisive question was designed for 1988. Because both surveys touched on the issue of peer review some discussion is possible. In 1986, scientists were asked about the use of peer review to monitor on-going and completed research. At that time 86% reported that research monitoring was an appropriate function of peer review. This degree of support remained constant among scientists in all scientific fields with the exception of physical scientists who demonstrated lesser support (80%). In terms of age and employment sector, the support was consistently high.

Survey participants in 1986 were next asked if systems sufficient to evaluate research were in place. Almost a third of the scientists agreed (32%); almost half responded negatively (46%) and the remaining 22% provided no opinion. Agreement that effective evaluation systems exist was strongest among tenured academicians and weakest among those employed in the private sector, among engineers, and among math and computer scientists.

In 1988, instead of examining peer review as a tool for monitoring, peer review as an allocation mechanism was

The greatest concerns I have with respect to the use of peer review in the grant awarding process are:

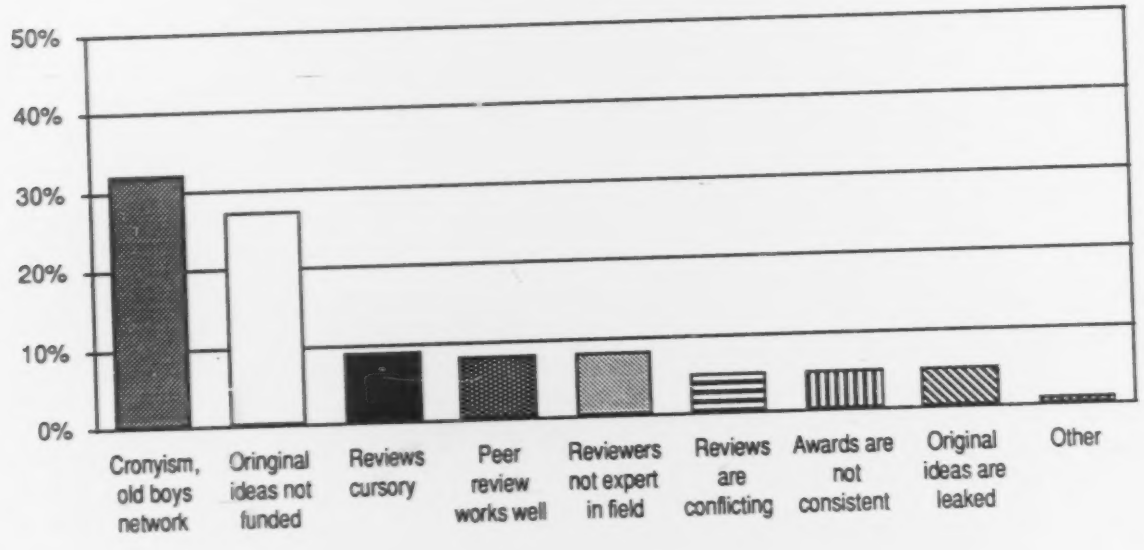

Fig. 3

investigated. In this context, the issue of peer review, like that of priority setting, tends to be sensitive because it relates to who controls the course of scientific research.

Scientists were asked what was wrong, if anything, with peer review as an allocation mechanism. About 24% declined to react to this issue, a substantial proportion of whom did not have personal experience in grant seeking.

A particularly dramatic finding involves the degree to which scientists were critical of the peer review process. Although prominently listed as the first of several choices in the survey instrument fewer than 8% indicated that" peer review works well as it is." The two most frequently cited responses by those who perceived problems in the peer review process were particularly troubling items: "Reviews are marred by cronyism, old boys networks, and insider politics" and "Original, non-mainstream ideas are unlikely to be funded." If one adds "Original ideas are sometimes 'appropriated' or 'leaked' by a reviewer or program officer," to these two responses the Survey results indicate a concern of scientists about **fundamental problems** (64% cited these three choices) rather than **technical problems** of the peer review process (28%) represented by the other critical responses.

With few exceptions, the uniformity of concerns among scientists regarding these rankings is striking. Scientists under 40 years old--particularly the 30-39 age group--were especially

critical of peer review. Older scientists, especially those 60 years and older, held a slightly more positive view. Concerns about cronyism decreased steadily with age. Computer scientists expressed a greater degree of concern about cursory or non-substantive reviews than did others. Tenured academicians were more inclined to believe that the peer review system works and to attribute shortcomings to technical faults, whereas non-tenured academicians were far and away the most critical of peer review (only 3% agree the system works) and the most likely to attribute problems to cronyism, old boys networks, and insider politics.

The generalized findings reported above, and the specific differentiation between tenured and non-tenured academics suggest that a central feature of the system by which allocation of public funds is made continues to require deep consideration of how it might be improved, or new mechanisms developed. The old saw that "it may not be good, but there is nothing in second place," has evidently outlived its usefulness.

Research Funding And Politics

1986 Many individuals, institutions, and interest groups compete for government research funds. I believe that research monies and research trends are tied too closely to prevailing political priorities and fashions. Agree Emphatically (13%) Agree in Substance (43%) Neither Agree Nor Disagree (15%) Disagree in

Substance (26%) Disagree Emphatically (4%)

1988 Research funds and monies are tied too closely to prevailing political priorities and fashions. Congress should not be involved in targeting research projects for federal funding. Agree Emphatically (27%) Agree in Substance (42%) Neither Agree Nor Disagree (13%) Disagree in Substance (15%) Disagree Emphatically (2%)

The reaction of scientists to this issue has changed significantly over time; however, the differences in the wording of the statement may, in part, account for some of the changes. It may be that in 1988 survey participants were responding to the concept of Congress targeting research projects more than to the more general idea of research funding being too closely tied to politics. The level of agreement with the statements increased from 55% to 70% and the level of disagreement dropped from 30% to 17%. The proportion of respondents expressing no opinion remained about the same. The shift in attitude is particularly obvious among biologists and health scientists, among scientists between 30 and 50 years of age, and among scientists employed in academia.

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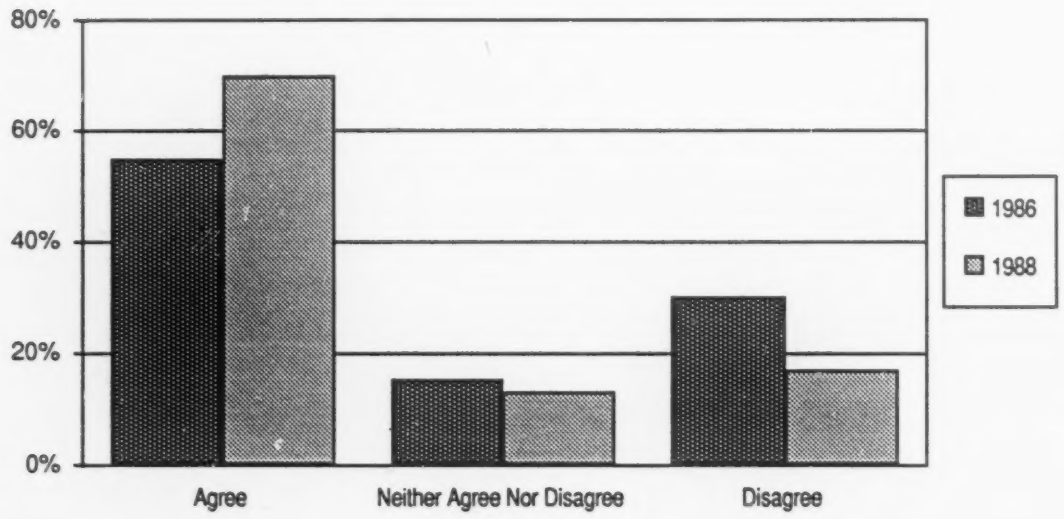


Fig. 4

Research Funds and Politics

	Sector	Disagree	Agree	No Opinion	Total*
1986	Acad/Tenured	34.39	54.79	10.48	100
1988		14.17	73.44	11.74	99
1986	Acad/Non-ten.	29.44	56.25	14.14	100
1988		11.59	75.33	12.88	100
1986	Government	28.82	57.96	13.06	100
1988		20.46	68.38	11.16	100
1986	Private	26.84	52.90	20.17	100
1988		21.95	63.69	14.05	100
1986	Other	20.00	63.59	16.41	100
1988		13.48	73.58	11.92	99
1986	Total	29.91	55.38	14.51	100
1988		16.97	69.52	12.87	99

*Totals may not round to 100 due to the omission of miscoded responses and non-responses.

Source: PERI

Fig. 5

Research Funds and Politics

	Age	Disagree	Agree	No Opinion	Total*
1986	20-29	23.48	53.52	23.00	100
1988		16.49	66.31	16.49	99
1986	30-39	28.61	55.21	15.71	100
1988		13.11	76.77	9.86	100
1986	40-49	33.67	53.82	12.31	100
1988		17.57	59.99	12.33	100
1986	50-59	31.57	55.84	12.40	100
1988		18.55	65.79	14.91	99
1986	>60	26.72	57.21	16.08	100
1988		18.33	67.57	13.34	99
1986	Total	29.93	55.37	14.50	100
1988		16.97	69.52	12.87	99

*Totals may not round to 100 due to the omission of miscoded responses and non-responses.

Source: PERI

Fig. 6

Research Funds and Politics					
	Science Field	Disagree	Agree	No Opinion	Total*
1986	Biological	31.10	56.62	11.87	100
1988		14.49	74.09	10.76	99
1986	Agricultural	24.72	59.55	15.36	100
1988		16.48	68.62	14.90	100
1986	Engineering	32.65	52.38	14.86	100
1988		23.09	62.76	13.52	99
1986	Health Science	31.74	53.34	14.92	100
1988		14.72	73.21	10.94	99
1986	Math/Comp. Sci	27.36	52.11	20.53	100
1988		16.92	66.67	16.41	100
1986	Physical Science	29.13	55.36	14.41	99
1988		15.87	70.06	13.54	99
1986	Social Science	25.47	57.67	16.85	100
1988		13.41	73.18	13.41	100
1986	Other	33.33	66.67	0.00	100
1988		18.60	65.12	12.40	96
1986	Total	29.90	55.50	14.50	100
1988		16.97	69.52	12.87	99

* Totals may not round to 100% due to the omission of miscoded responses or non-responses.

Source: PERI

Government And The Research Agenda

1986 Democratic government is responsible to the voters on questions of dispensation of tax monies, and it has a large role in whatever expenditure process it initiates. I believe the proper role for government with regard to the funding of science is to define what should be investigated, thereby providing scientists with a "research agenda," and to require delivery of research output, on the premise that a contractual relationship exists between scientists and society. Agree Emphatically (6%) Agree in Substance (25%) Neither Agree Nor Disagree (6%) Disagree in Substance (33%) Disagree Emphatically (30%)

1988 I believe the proper role for government with regard to the funding of science is to define what should be investigated, thereby providing scientists with a "research agenda." Agree Emphatically (4%) Agree in Substance (22%) Neither Agree Nor Disagree (14%) Disagree in Substance (34%) Disagree Emphatically (26%)

Slight differences in the wording of the two questions notwithstanding, opinions have not varied significantly over time with respect to the issue of whether elected representatives and bureaucrats should provide scientists with a research agenda. The majority of survey participants in 1986 and 1988 disagreed with

2

this notion (63% and 60%, respectively). The level of agreement dropped somewhat (from 31% in 1986 to 26% in 1988). The percentage of respondents providing no opinion increased over time as well (from 6% in 1986 to 14% in 1988). In terms of scientific field, the trend remains constant with the exception of biologists whose views did not alter at all over time. In terms of age, the proportion of the youngest scientists (ages 20-29) reporting that there should be no government mandated research agenda dropped 12 percentage points. Disagreement over the idea of government-driven research also increased slightly among scientists working in the government as well as in the private sector but trends in response remained relatively constant for other groups.

Congress Should Provide a Research Agenda

	Sector	Disagree	Agree	No Opinion	Total
1986	Acad/Tenured	72.96	22.21	4.55	100
1988		64.37	20.97	14.17	100
1986	Acad/Non-ten.	76.97	16.94	5.76	100
1988		70.39	17.38	12.02	100
1986	Government	52.23	43.79	3.82	100
1988		54.19	32.79	13.02	100
1986	Private	50.26	41.48	8.09	100
1988		52.31	33.13	14.26	100
1986	Other	62.40	30.40	7.20	100
1988		61.14	24.87	13.99	100
1986	Total	63.13	30.87	5.75	100
1988		60.00	25.94	13.56	100

Source: PERI

Fig. 8 2

Congress Should Provide a Research Agenda

	Age	Disagree	Agree	No Opinion	Total*
1986	20-29	76.52	17.84	5.63	100
1988		64.91	18.59	16.14	100
1986	30-39	70.69	22.86	6.45	100
1988		63.67	23.85	12.23	100
1986	40-49	63.66	31.69	4.10	99
1988		59.80	25.51	14.36	100
1986	50-59	61.69	32.15	5.74	100
1988		58.64	27.45	13.53	100
1986	>60	54.52	38.63	6.85	100
1988		57.49	28.96	13.23	100
1986	Total	63.18	30.87	5.71	100
1988		60.00	25.94	13.56	100

*Totals may not round to 100% due to the omission of miscoded responses and non-responses.

Source: PERI

Fig. 9

Congress Should Provide a Research Agenda

	Science Field	Disagree	Agree	No Opinion	Total*
1986	Biological	73.40	21.89	4.32	100
1988		66.85	21.84	10.65	99
1986	Agricultural	50.00	41.79	8.21	100
1988		48.24	36.86	14.51	100
1986	Engineering	50.30	43.75	5.94	100
1988		48.22	35.71	15.82	100
1986	Health Science	67.20	26.12	6.37	100
1988		62.26	24.90	11.70	99
1986	Math/Comp. Sci	62.24	31.39	5.85	99
1988		57.95	23.59	18.46	100
1986	Physical Science	64.76	28.86	6.09	100
1988		63.84	22.75	13.02	100
1986	Social Science	68.04	24.06	7.52	100
1988		66.66	18.48	14.86	100
1986	Other	66.67	22.22	11.11	100
1988		61.24	18.61	16.28	96
1986	Total	63.20	30.90	5.70	100
1988		60.00	25.94	13.56	100

* Totals may not round to 100% due to the omission of miscoded responses or non-responses.

Source: PERI

A Cabinet-level Department Of Science

1986 I believe that there should be a national cabinet level Department of Science. Agree Emphatically (19%) Agree in Substance (28%) Neither Agree Nor Disagree (15%) Disagree in Substance (20%) Disagree Emphatically (17%)

1988 I think that the possible efficiency gains and prestige enhancement related to the creation of a cabinet level Department of Science and Technology would outweigh potential problems associated with centralization of decision-making. Agree Emphatically (11%) Agree in Substance (32%) Neither Agree Nor Disagree (30%) Disagree in Substance (17%) Disagree Emphatically (8%)

Between 1986 and 1988, scientists appear to have relented somewhat in their views with regard to the creation of a cabinet-level Department of Science. In 1986, almost half of the scientists surveyed (47%) supported the idea of a Department of Science and 19% were emphatic in their agreement; however, 38% disagreed and 17% disagreed emphatically. In 1988, although the level of support diminished slightly (43%) and the support was less emphatic (11% expressed emphatic agreement) the major change occurred in the level of disagreement. Only slightly over one-quarter of survey participants (26%) in 1988 reported that

there should not be a new cabinet-level department compared 37% in 1986, and only 8% were emphatic in their disagreement compared to 17% in 1986. The proportion of scientists expressing no opinion doubled from 1986 to 1988, from 15% to 30%.

There were, for the most part, no significant differences in response in terms of employment sector, age, or scientific field. The single exception relates to engineers, who constitute the only group which actually increased its support for a Department of Science (from 43% in 1986 to 47% in 1988).

1986 I believe that there should be a national cabinet level Department of Science.

1988 I think that the possible efficiency gains and prestige enhancement related to the creation of a cabinet level Department of Science and Technology would outweigh potential problems.

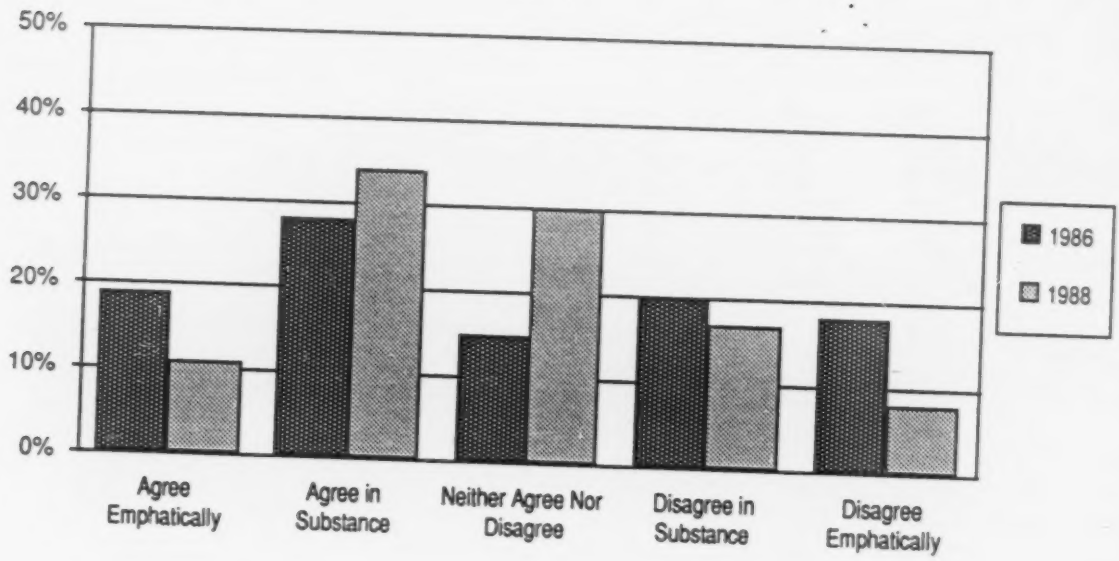


Fig. 11 3

Cabinet Level Department of Science

	Sector	Disagree	Agree	No Opinion	Total*
1986	Acad/Tenured	34.67	48.62	16.44	100
1988		22.91	44.46	30.77	98
1986	Acad/Non-ten.	33.94	47.02	18.87	100
1988		26.61	39.70	31.97	98
1986	Government	42.72	43.68	13.44	100
1988		28.84	42.32	27.21	98
1986	Private	40.63	46.42	12.95	100
1988		28.62	43.28	26.87	99
1986	Other	38.46	48.72	12.82	100
1988		25.91	39.38	33.68	99
1986	Total	37.72	46.98	15.15	100
1988		25.67	42.77	29.81	98

*Totals may not round to 100 due to the omission of miscoded responses and non-responses.

Source: PERI

Cabinet Level Department of Science

	Age	Disagree	Agree	No Opinion	Total*
1986	20-29	36.32	43.87	19.81	100
1988		24.21	38.59	36.49	99
1986	30-39	38.78	43.01	18.10	100
1988		24.59	41.57	32.71	99
1986	40-49	37.10	48.37	14.35	100
1988		25.62	41.26	31.73	99
1986	50-59	38.84	48.48	12.67	100
1988		27.70	43.23	26.44	97
1986	>60	36.46	48.33	14.90	100
1988		25.49	46.42	26.57	98
1986	Total	37.67	47.03	15.16	100
1988		25.67	42.77	29.81	98

*Totals may not round to 100 due to the omission of miscoded responses and non-responses.

Source: PERI

Cabinet Level Department of Science

	Science Field	Disagree	Agree	No Opinion	Total*
1986	Biological	35.36	48.23	16.21	100
1988		23.82	40.51	34.14	98
1986	Agricultural	42.65	39.63	17.36	100
1988		24.31	40.79	33.73	99
1986	Engineering	42.45	43.29	14.15	100
1988		27.68	47.06	23.47	98
1986	Health Science	35.76	50.32	13.61	100
1988		26.04	43.39	29.81	99
1986	Math/Comp. Sci	38.50	46.52	14.97	100
1988		28.72	41.03	28.21	98
1986	Physical Science	35.53	49.86	13.67	99
1988		25.82	43.81	28.57	98
1986	Social Science	37.36	43.02	19.62	100
1988		23.19	37.68	37.32	98
1986	Other	44.44	44.44	11.11	100
1988		27.90	41.09	25.58	95
1986	Total	37.67	46.99	15.18	100
1988		25.67	42.77	29.81	98

* Totals may not round to 100% due to the omission of miscoded responses or non-responses.

Source: PERI

SECTION TWO

Questions Unique to the 1988 Survey

Science Transcends National Concerns

I believe that science transcends national concerns and any attempts to confine particular research efforts to a particular country will diminish the progress of science in that country as well as elsewhere. Agree Emphatically (37%) Agree in Substance (42%) Neither Agree Nor Disagree (7%) Disagree in Substance (10%) Disagree Emphatically (3%)

That the pursuit of science is of greater import than political or national boundaries is a view which pervades the scientific community, regardless of scientific field or demographic background. Between 70% and 86% of scientists in each of the subgroups examined (i.e., age, field of science, employment sector) agreed or emphatically agreed with this view. Engineers and scientists working in the private sector were most likely to dissent, although the level of disagreement was still quite low (20% and 21%, respectively disagreed).

National Competitiveness Requires Strong Basic Research

In my opinion, the ability of any country to compete successfully

in the world economy is directly related to the quality of basic research in that country. Agree Emphatically (34%) Agree in Substance (42%) Neither Agree Nor Disagree (12%) Disagree in Substance (10%) Disagree Emphatically (2%)

While scientists concur that science transcends national concerns, there is also a strong sentiment that the conduct of basic research is critical to a nation's ability to compete in the international arena. This belief is shared by at least 70% of scientists regardless of age, employment sector, and field of science. In some respects this is an astounding result: American scientists are certainly aware of both the applied character of Japan's research establishment and Japan's super competitive position relative to the United States; and they have also demonstrated their skepticism of political hype, yet they appear to embrace this paradox.

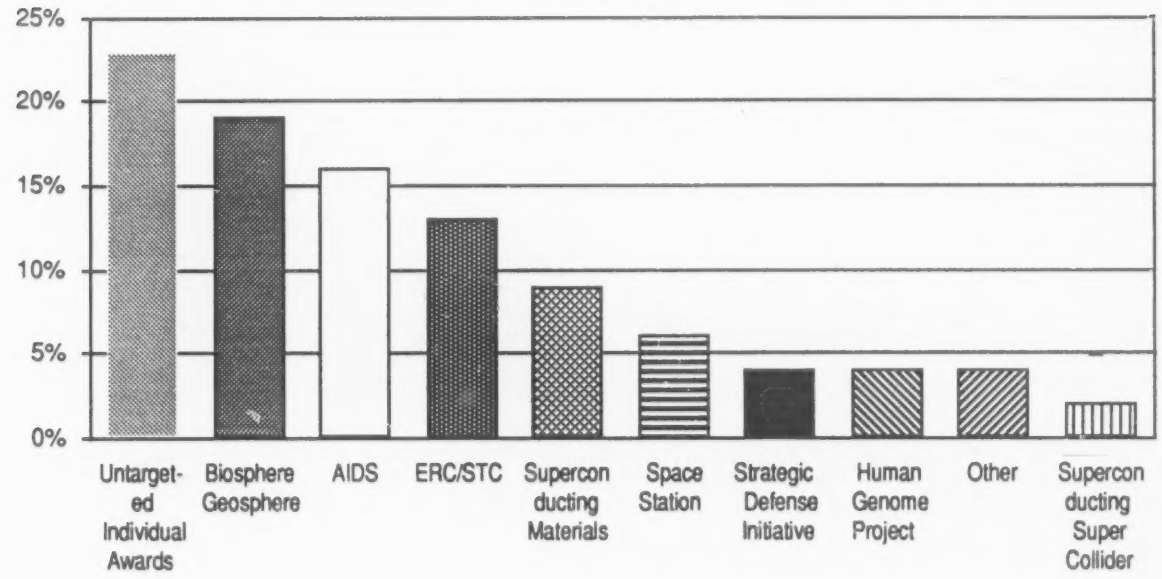
Priority Setting In Science

I think the three best uses of public funds for scientific research, at this point in time, are: Untargeted individual research awards (23%) Biosphere/Geosphere systems (19%) AIDS (16%) Engineering Research Centers and Science and Technology Centers (13%) Superconducting materials (9%) Space station (6%) Strategic Defense Initiative (4%) Human genome project (4%) Other (4%) Superconducting super collider (2%)

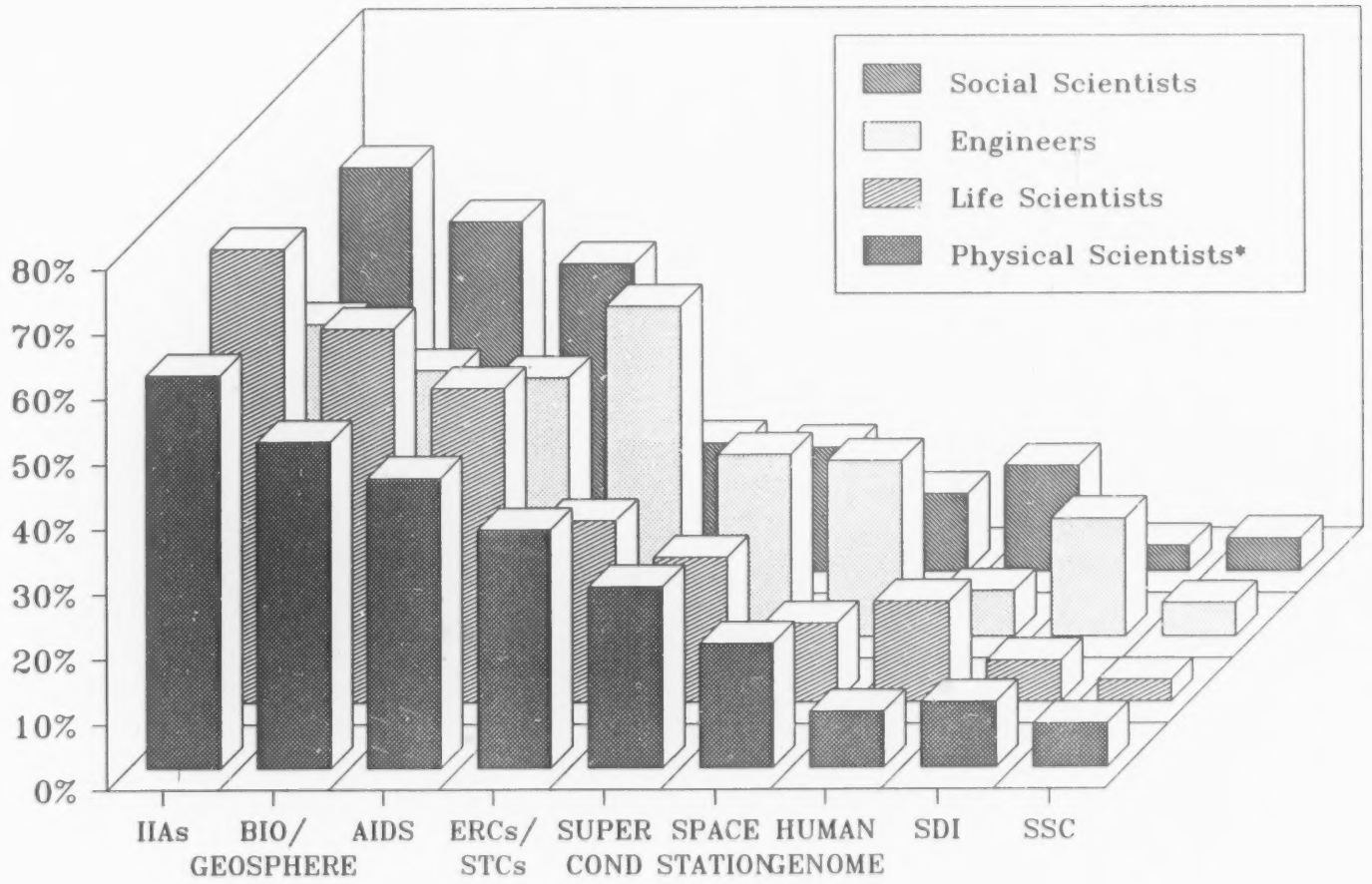
Demand for "priority setting" has been used by some to urge the scientific community to declare what is truly important research worthy of public support. Although it seems intuitively obvious that short of turning such a decision over to powerful scientific and engineering elite spokespersons there is no way to achieve a consensus on priorities. Each researcher is engaged in what she or he believe to be important, and the idea that, for example, psychologists would agree to reduced public funding of psychology for the greater good of research in particle physics is not credible.

A plausible, but imperfect approach to priority setting by scientists was developed by Sigma Xi in its 1988 Survey. Opinions of scientists and engineers were sought on what scientific research projects they would choose to support. The ranking of "untargeted research awards," sometimes referred to as Individual Investigator Awards (IIAs), as the clear first choice by a substantial margin may be a signal to Congress and funding agencies that scientists are concerned about preserving the diversity of lines of scientific thought, preferring "little science" to "big science." Major support for Biosphere/Geosphere programs and AIDS research may reflect a deep concern for both the external and internal environment of human life. The strong support for the Engineering Research Centers and Science and Technology Centers programs of the National Science Foundation

I think the best use of public funds for scientific research, at this point in time, are:



Percent Citing Project as One of Three Most Important



* includes Math and Computer Science

suggests this funding experiment may have captured the interest of the respondents. One might speculate that this result may be indicative of the desire of scientists to focus efforts from time to time on multi-disciplinary frontiers that emerge from path breaking scientific inquiry.

These preferences can be contrasted with the dramatically weak support for major "big science" initiatives like the space station, Strategic Defense Initiative, human genome project, and even weaker support for the superconducting super collider, in which fewer than 1 in 50 respondents chose this major project as one of the three best uses of public funds for scientific research. Nearly half of those selecting the category "other" specified health related areas as important topics.

Analysis of the results of this priority setting exercise indicates that engineers and health scientists have different priorities than do other scientists, particularly those in the biological sciences. Engineers selected the ERCs/STCs as their first choice, and then followed the order of choice of the other respondents; however, they are also the strongest supporters of the high technology projects such as the space station, SDI, and superconducting research. Health scientists ranked AIDS research second to untargeted research awards as a research priority. Biologists, by contrast, adopted the same ranking as all other scientists, but ranked untargeted awards first by an exceptional

margin and demonstrated especially strong support for Biosphere/Geosphere programs. Scientists working in the private sector provided a ranking that differed slightly from the group as a whole, ranking Biosphere/Geosphere projects slightly higher than untargeted projects and AIDS fourth, behind ERCs/STCs. Scientists in academia viewed the human genome project as being of more value than the space station. Scientists 29 years and younger ranked both AIDS and Biosphere/Geosphere programs before untargeted awards.

Fundamental Uncertainty Of Basic Research And Demand For Payoffs

It is in the nature of basic research that its value cannot be pre-determined and in retrospect, some research can be viewed as not being of value; however, because the value cannot be predetermined, the funding and pursuit of basic research is not a mistake. Agree Emphatically (52%) Agree in Substance (40%) Neither Agree Nor Disagree (4%) Disagree in Substance (2%) Disagree Emphatically (1%)

When the taxpayers fund basic research, their representatives cannot require a specific payoff because no scientist can guarantee a result in advance of the research undertaking. Agree Emphatically (56%) Agree in Substance (36%) Neither Agree Nor Disagree (3%) Disagree in Substance (4%) Disagree Emphatically (1%)

The results of the survey indicate that scientists view the role of the federal government in scientific research as that of a funding source for both basic and applied research. Beyond the provision of funds, however, it appears that the majority of scientists do not believe that government should have an active role. Scientists overwhelmingly concurred that the inability to pre-determine the value of basic research in no way diminishes the importance of funding such research. This view was shared by scientists of all ages, in all fields of science, and in all employment sectors. No more than 4% of scientists in any subgroup disputed this notion. Furthermore, at least 90% of scientists in all subgroups agreed that there are no guarantees in the conduct of basic research and that elected officials should not require any specific payoffs.

Government Should Fund Only Applied Research

If representatives of the voting public stipulate immediate and measurable returns on public investment of science, then government should only fund applied research. Agree Emphatically (8%) Agree in Substance (22%) Neither Agree Nor Disagree (12%) Disagree in Substance (26%) Disagree Emphatically (30%)

This issue touches upon scientists responsibilities to the public and the role of the public in regard to research funding. Survey

results indicate that, in general, regardless of public opinion, scientists reported that basic research should be funded by the government. This belief was held to be strongest among scientists under 50 years old, among social and biological scientists, and scientists in academia. Scientists working in the private sector were most apt to indicate that government responds to the wishes of the voting public.

Government Should Not Even Fund Applied Research

In general, applied research should not be funded by the government because if it is sufficiently valuable, it will be privately supported. Agree Emphatically (5%) Agree in Substance (17%) Neither Agree Nor Disagree (13%) Disagree in Substance (41%) Disagree Emphatically (23%)

While, for the most part, scientists disagreed with the notion that applied research should be funded privately, the extent to which scientists disagreed varied somewhat among groups, and the extent to which scientists expressed no opinion was higher than among other related survey issues. Agricultural scientists and math and computer scientists were most apt to support the notion of government funding of applied research (69% and 72%, respectively) as were scientists employed by the government (71%). On the other hand, older scientists (over 60 years) were least apt to support public funding of applied research (58%).

Congressional Earmarking Of Science Funds Is Bad

It is the nature of democratic politics that congressional representatives seek funding for their states or districts; however, using this method to allocate public funds for science is bad. Agree Emphatically (38%) Agree in Substance (40%) Neither Agree Nor Disagree (12%) Disagree in Substance (9%) Disagree Emphatically (2%)

Scientists expressed unanimity that pork barrel funding is wrong and this opinion was held consistently across all subgroups of scientists. The only observable variations in response were related to the level of agreement: math and computer scientists and physical scientists and scientists between 20-29 and 40-49 years of age were less apt to express emphatic agreement than other scientists. This result should be considered along with results of the peer review question discussed in the Section One. Earmarking of research funds by those in political positions is a fear that makes some cling tenaciously to peer review despite the expression of wide spread concern over its efficacy.

Scientists Have A Responsibility To Increase Public Understanding

As a scientist, I feel that I have a responsibility for improving the public understanding of the long term value of basic research.

Agree Emphatically (45%) Agree in Substance (45%) Neither Agree Nor Disagree (7%) Disagree in Substance (2%) Disagree Emphatically (1%)

Scientists feel strongly about their responsibility to educate the public about basic research. This view is held by the great majority of scientists across all fields of science, employment sectors, regardless of age.

On Recommending Science As A Career

The way things are going in scientific research today, I would recommend it as a career. Agree Emphatically (20%) Agree in Substance (48%) Neither Agree Nor Disagree (18%) Disagree in Substance (12%) Disagree Emphatically (2%)

While a strong two-thirds majority of scientists would recommend science as a career, the extent of agreement varies. With respect to scientific field, biologists, health scientists, and agricultural scientists are less apt to recommend a scientific career than are others (20%, 17%, and 14%, respectively disagreed with the above statement). Non-tenured scientists in academia are also less forceful than others in recommending science as a career (22% disagreed) as were scientists under 50 years of age. One can not help but be

The way things are going in scientific research today, I would recommend it as a career.

17
Figure ~~One~~: Would Recommend a Science Career

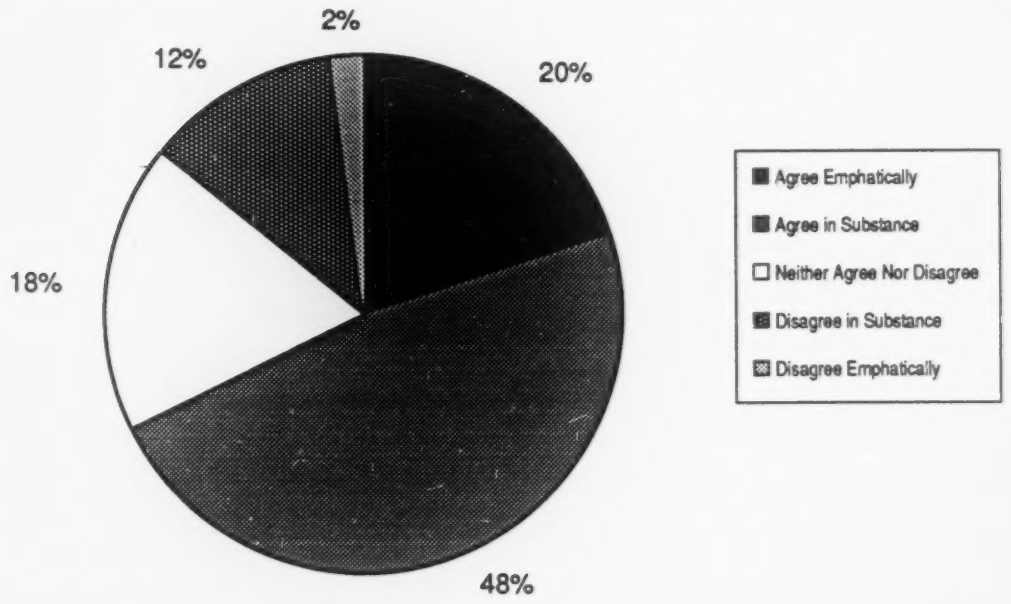


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Figure ~~Two~~: Would Recommend a Science Career by Gender

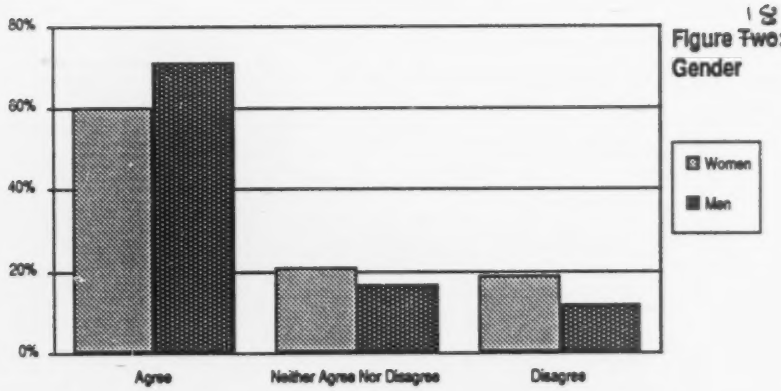

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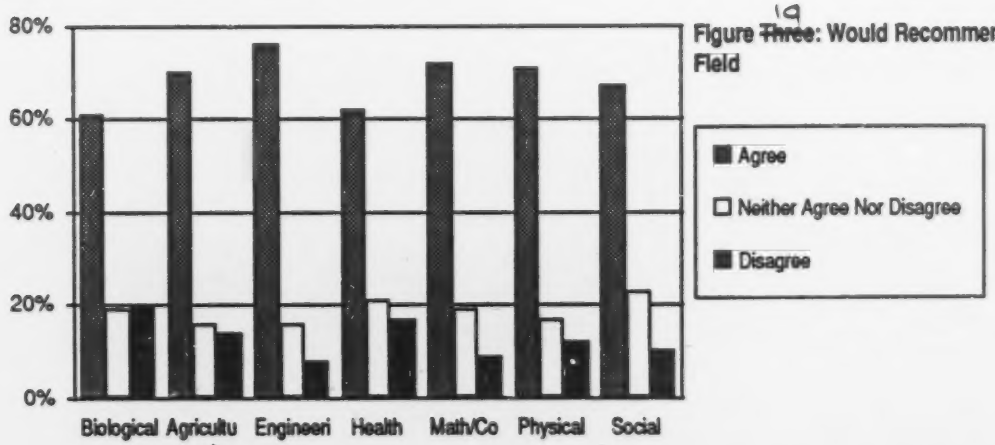
Figure ~~Three~~: Would Recommend a Science Career by Field



impressed by the enthusiasm for a career in science, a message the scientific community would do well to broadcast more forcefully.

Whether Science Funding Should Emphasize Teaching Or Research

If the total funding for science were to remain about the same, I believe a greater share should be devoted directly to the education of students rather than to research. Agree Emphatically (7%) Agree in Substance (27%) Neither Agree Nor Disagree (29%) Disagree in Substance (30%) Disagree Emphatically (7%)

When put to the test of deciding whether, in the situation of static funding availability for science, more resources should go to research or to education, survey respondents were fairly evenly divided in their opinions, with about a third supporting more funding for education and slightly more (37%) dissenting. However, it is noteworthy that almost a third of scientists (29%) surveyed expressed no opinion on the subject. Those in private practice were somewhat more apt to support education over research and mathematics and computer scientists were somewhat more apt to support research endeavors. This result is more dramatic than it first appears: it corresponds to the strong support for public understanding of science discussed in Section One, and lends even more weight to the interesting results of the next question.

If the total funding for science were to remain about the same, I believe a greater share should be devoted directly to the education of students rather than to research.

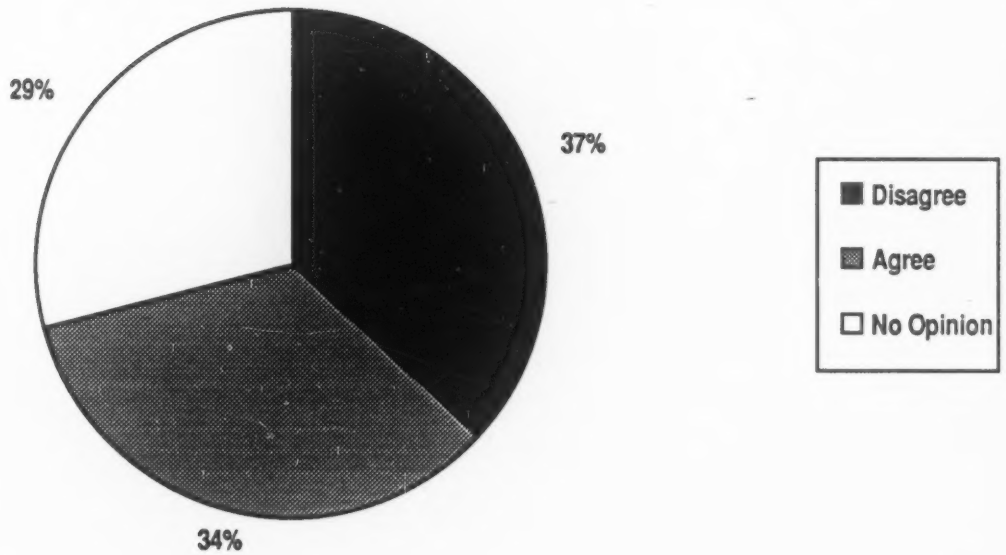


Fig. 20

Double Load Of Teaching and Research Hurts Both Functions

University requirements for scientists to perform as both researcher and educator are ultimately detrimental to both the research and the education process. Agree Emphatically (9%) Agree in Substance (18%) Neither Agree Nor Disagree (10%) Disagree in Substance (38%) Disagree Emphatically (25%)

It is remarkable, given the conventional wisdom that time in the classroom takes away from research that about two-thirds of scientists report that requirements to perform as teachers and educators do not hinder the outcomes of either task. Engineers, math and computer scientists, and scientists working in the private sector are somewhat more likely to perceive a difficulty related to performing in both roles than are other scientists.

SECTION THREE

Gender Partitioned 1988 Survey Data

To examine differences in viewpoint in terms of gender, it is useful to have some understanding of how men and women in science differ in terms of socio-demographic characteristics, choice of scientific field, and employment.

Science and engineering tend to be male domains, and this, of course, was reflected in the survey. Of survey respondents reporting gender, 85% were men and 15% women. This accords with other national estimates, especially given the under representation of social scientists in the sample.[6] Men tend to be older; about three-quarters of the men in the survey were over 40 and 28% were over 60. Half of the women surveyed were under 40 years old and only 11% were over 60. The male scientist is married (85%), with children (77%). Slightly more than half of female scientists are married and 29% (as compared with 9% of the men) have never been married. Furthermore, fewer than 40% reported having children.

Disparities in personal income were also apparent. Whereas 55% of the men participating in the survey reported personal incomes exceeding $50,000, almost two-thirds of the women reported personal incomes of less than $40,000. To some degree these differences can be attributed to the different age structures for

men and women in the sample (income elevation of the older male cohort would be expected because they are further along in their careers), but, it does not appear that all of the difference is washed out because of age.

While all fields of science are represented by both men and women, men are predominant in engineering and women demonstrate a greater tendency to select the social sciences as a career choice. This fact has, in the past, been used by some as a kind of justification of lower overall funding rates for women, the argument being that "if women chose to work in the **hard** scientific fields they would do as well as men." This circular argument is possibly as revealing of a literal "old boys" characteristic of the Science Establishment as it is offensive to the intellect of women scientists. Trends in terms of employment sector are consistent for men and women, with the greatest proportion reporting employment in academic tenured positions (38%), followed by private practice (30%), non-tenured academic positions (14%), and government (13%). Twice as many men as women have held administrative positions.

An examination of survey data in terms of gender reveals that men and women hold similar views on many issues related to science; however, there is considerable difference in the degree of concurrence or dissent on each issue. For example, whereas the majority of scientists of both genders disagreed with the notion

that Congress should provide a research agenda, this sentiment was held by 70% of women as compared with 58% of men. In this section, findings concerning those issues in which differences were found are discussed.

In reviewing the data, some patterns begin to emerge. It appears that gender differences are minimal when issues related to the value and funding of basic and applied research are addressed. Men and women also concur with regard to the responsibility of scientists to educate the public about the value of basic research. However, differences in opinion are apparent when survey responses are examined relative to science and politics, and to the way scientists are affected personally by science issues.

The most significant difference with respect to science and politics is that women indicate a preference to separate science from political concerns and they tend not to have as strong opinions on political issues. While general trends in response are similar, women show a much stronger tendency to respond "neither agree nor disagree" to questions with political overtones.

Science Transcends National Concerns

I believe that science transcends national concerns and any attempts to confine particular research efforts to a particular country will diminish the progress of science in that country as well as elsewhere.

While both men and women viewed science as being more significant than a nation's politics, women were stronger in their support (87% of women versus 78% of men agreeing).

National Competitiveness Depends Upon Basic Research

In my opinion, the ability of any country to compete successfully in the world economy is directly related to the quality of basic research in that country.

Scientists of both sexes also concurred that the conduct of basic research is essential to a country's competitiveness; however, 18% of women reported having no opinion on this issue as compared with 11% of men.

Earmarking Of Science Funds By Congress Is Bad

It is the nature of democratic politics that congressional

5

representatives seek funding for their states or districts; however, using this method to allocate public funds for science is bad.

Scientists expressed unanimity that pork barrel funding is wrong and this opinion was held by both men and women. Again, women were less apt to provide a response to this issue; 18% of women and 11% of men neither agreed nor disagreed.

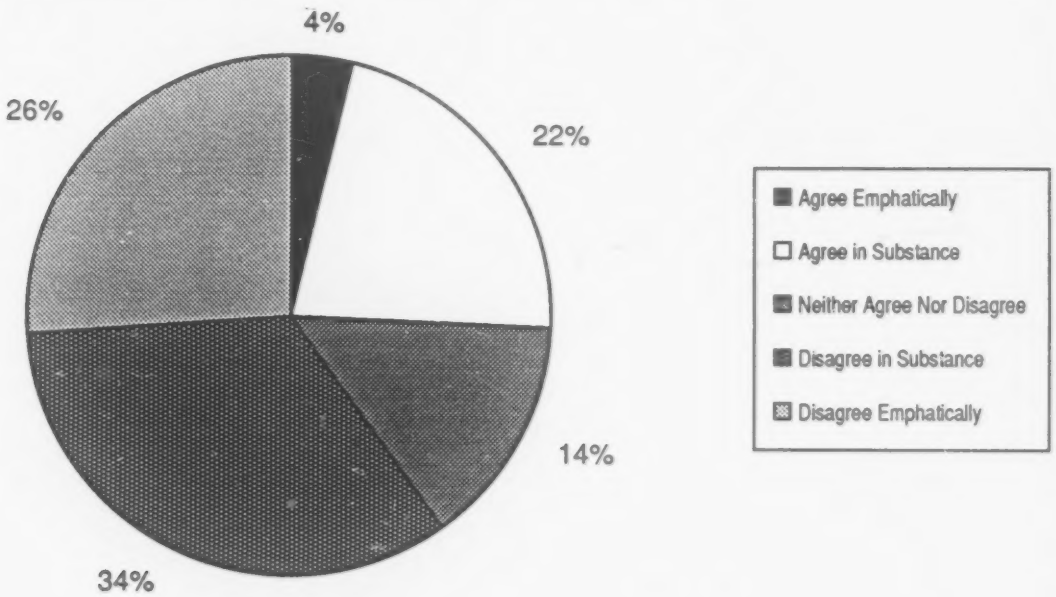
Congress Should Provide A Research Agenda

The proper role for Congress with regard to the funding of science is to define broadly what should be investigated, thereby providing scientists with a "research agenda."

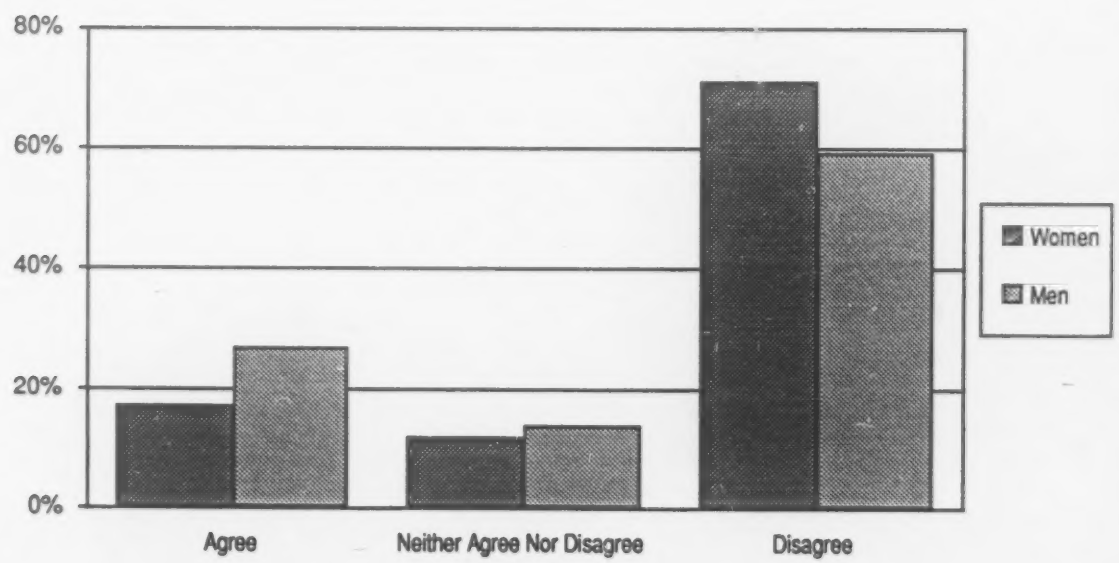
The preference of women to separate politics from scientific concerns is reinforced in findings related to the role of government in setting a research agenda for scientists. Less than a fifth of the women surveyed (18%) supported the notion of government agents providing scientists with a research agenda; however, more than a fourth (28%) of the men responding showed support for government taking such an active role.

I believe the proper role for government with regard to the funding of science is to define what should be investigated, thereby providing scientists with a "research agenda."

21
Figure ~~One:~~ Congress Should Provide a "Research Agenda"



22
Figure ~~Two:~~ Congress Should Provide a "Research Agenda" by Gender



Research funds and monies are tied too closely to prevailing political priorities and fashions. Congress should not be involved in targeting research projects for federal funding.

Fig. 23
Research Funds and Politics

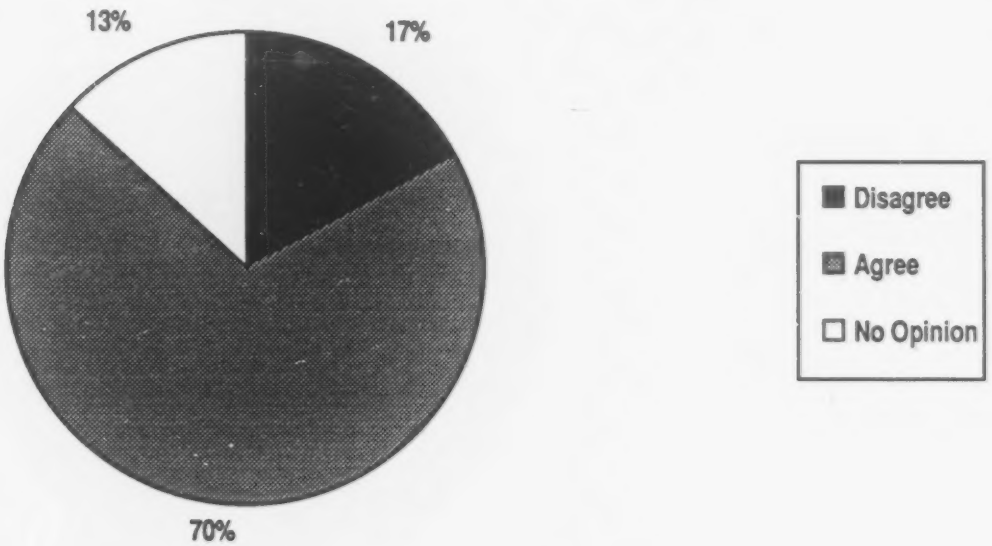
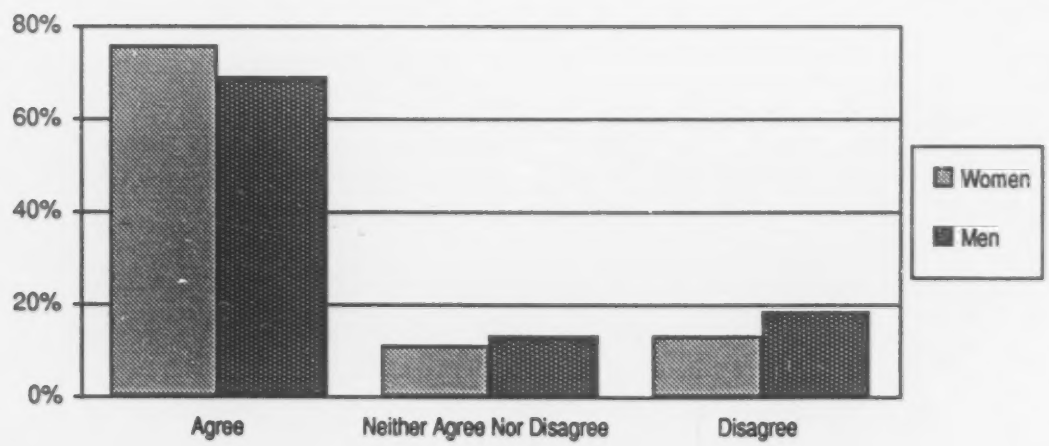


Fig 24
Research Funds and Politics by Gender



Research funds and monies are tied too closely to prevailing political priorities and fashions. Congress should not be involved in targeting research projects for federal funding.

More than three-quarters of female scientists (76%) as compared to 69% of males concurred that Congress should not be involved in targeting research projects for federal funding.

Preference For A Department Of Science

I think that the possible efficiency gains and prestige enhancement related to the creation of a cabinet level Department of Science and Technology would outweigh potential problems associated with centralization of decision-making.

Whether or not the development of a Department of Science would be of value is an issue where men hold somewhat stronger opinions than do women. More men than women agreed with the concept (44% versus 38%, respectively) and more men than women disagreed (27% versus 22%, respectively). Women were much less likely to express an opinion on the issue; 38% of women neither agreed nor disagreed with the notion of a Department of Science as compared to 28% of the men.

5

Career Satisfaction Issues For Women

As noted previously, the other major area where the views of women scientists diverge from those of the men relates to personal issues and issues in which scientists have an immediate and personal stake. It appears that women are somewhat less satisfied than men in their scientific careers.

The way things are going in scientific research today, I would recommend it as a career.

This issue speaks directly to career satisfaction and while the majority of scientists responded positively, gender differences are apparent. Of males, 69% reported that they would recommend a scientific career as compared with 59% of women. Furthermore, 21% of men and only 13% of women expressed emphatic agreement with the idea.

University requirements for scientists to perform as both researcher and educator are ultimately detrimental to both the research and the education process.

Men are more emphatic in their belief that the dual role of researcher and educator is not detrimental. Almost two-thirds of the men surveyed (64%) disagreed that it is a concern and 26%

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University requirements for scientists to perform as both researcher and educator are ultimately detrimental to both the research and the education process.

Fig. 25
Dual Role is Detrimental

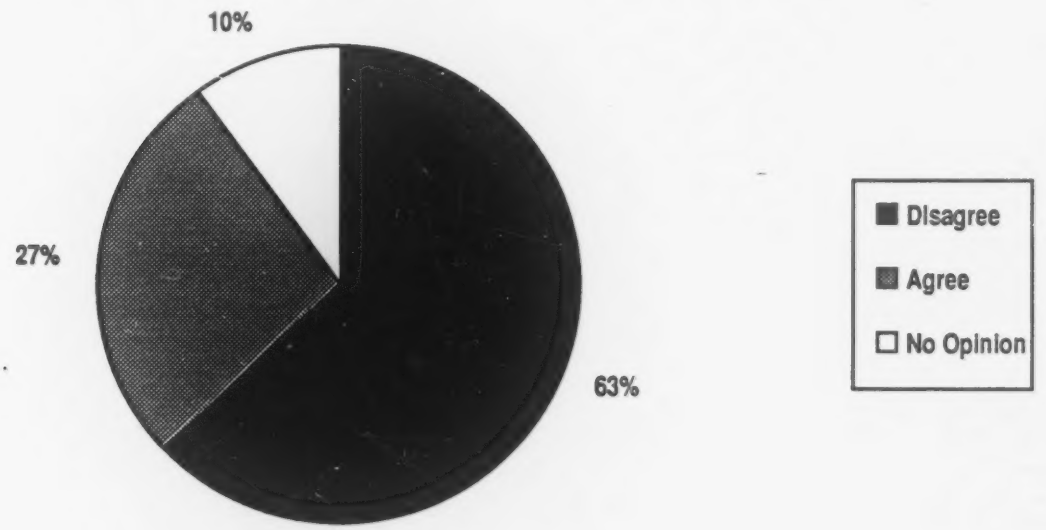
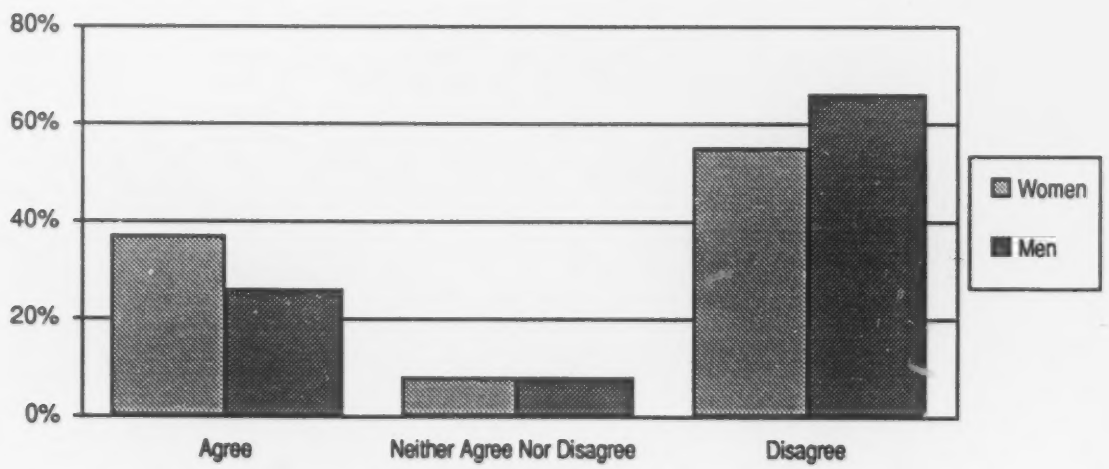


Fig. 26
Dual Role is Detrimental by Gender



disagreed emphatically. On the other hand, only slightly more than half of the women (54%) disagreed that performing in a dual role is detrimental and 18% were emphatic in this view.

On the matter of peer review, most of the scientists surveyed are very directly affected by the process and most are dissatisfied with the system. However, twice the proportion of men as women (7% versus 3%, respectively), reported that the peer review process works. The more important observation is that the proportion of men and women selecting each concern is extremely close--not varying by more than a few percentage points in any case.

SECTION FOUR

Summary Narrative

The preceding three sections of this report juxtaposed questions with the distribution of responses shown in the text and figures. Limited commentary and speculation in these parts has left the field open for hypothesizing by the reader. The concluding section raises a few speculations from an examination of certain aggregates of answers. It does so without assertion of specific causal linkages; rather it synthesizes ideas emergent from consideration of the context and the content of the answers to the survey questions. In doing so it raises questions not answerable with reference to the current surveys, but which are important to address in future investigations, be they by Sigma Xi or by other inquiring agents.

The Comparative Picture

The salient aspects of the comparison between 1986 and 1988 may be divided into two parts, the questions relating research and politics, and those requiring ranking of issues facing science and of peer review concerns.

For those questions about which strict comparison is possible the elapse of two years would not be expected to produce much

change in attitude or opinion, which was indeed the case of whether government should provide a research agenda (and which was substantially the case concerning the desirability of a Department of Science). However, when a large change is recorded, as was true when the question of the influence of prevailing political fashions on the availability of research monies, then attention is aroused. Was the dramatic rise in discontent over research funds being tied to politics solely an artifact of the introduction of the word "Congress" into the 1988 question, thereby setting off a specific alarm system; or has there been a palpable shift in sentiment, the deepest roots of which are found among 30 to 50 year old academics in the biological and health sciences?

Where ranking of concerns was recorded, changes in those related to the important issues facing science may have been related to a slight change in the wording of the question between 1986 and 1988. In 1986 a longer list of options and a request for the <u>two</u> most important issues was asked; in 1988, after a pre-test of the instrument revealed a similar distribution to 1986 results the instrument was altered to focus on the single most important issue among the four leading issues from 1986 and the pre-test. The jump in interest in "public understanding of science" may be the result of intense discussion of this issue in the scientific community during the period between the two surveys.

Peer review comparisons between surveys are highly

qualitative, in the sense of incomparability of questions; however, taken together, the responses in 1986 and 1988 signal a very important issue for the scientific community and for those who have responsibility for allocating funds for science and engineering.

In 1986, the role of government as a responsible agent to monitor research quality through peer review was strongly affirmed; but trust in the efficacy of the mechanisms to evaluate research was low enough to arouse suspicions about the process and to provoke the much more specific question asked 1988. The answers to this 1988 question are ominous and shall surely require deeper analysis than can be undertaken here, and inspire further questions by those concerned with the conduct of scientific inquiry.

The Sigma Xi survey is likely to be repeated in the future; even so, other, more specialized survey research entities which study different scientific and engineering populations would do well to consider addressing peer review issues along the lines opened up by Sigma Xi.

The 1988 Survey: Dimensions of Politics and Education

The questions selected from the 1988 survey for consideration here open a window on the opinions of scientists and engineers

concerning their obligations under the "social contract" formulation popularly deployed to characterize the relationship of the research functions of these professions to the State. Briefly stated, this formulation states: "scientists and engineers will undertake research to the best of their ability and share the results freely in return for adequate support by the Federal government for their research." That it produces conflicts in a democratic society is doubtless, as the results of the 1988 survey indicate.

To begin, the respondents are emphatic in stating that science is transnational, which, by implication, indicates that researchers do not feel bounded in work that is supported by the United States taxpayer.

Next, four questions draw out aspects of the tension between science and politics. The respondents overwhelmingly asserted that even though the results of basic research can not be predetermined such activity is deserving of support; furthermore, the respondents agree more than 10 to 1 that legislators can not require a specific payoff from basic research efforts in advance of the undertaking of the research. And, when asked if government should fund only applied research whose "answer" (i.e. product or process) is known in advance, only 3 in 10 agreed. More emphatically still was the response to the assertion that government should let the private sector alone fund applied research--only 2 in 10 agreed.

These four questions taken together portray a population that may view public support of their enterprise as an entitlement, or at the very least, that their view of what is best for society-at-large is coincident with their own interests. This should surprise no one who has addressed interest group theory in politics or public choice theory in economics, but such results are likely to disappoint those who have a large stake in sustaining the myth of the "social contract."

More evidence of the distance between the respondents and the working of democratic government may be found in the near unanimous rejection of science funding allocation by Congressional earmarking, where only 1 in 10 disagreed that such an allocative mechanism is bad.

Given the foregoing sequence, the question of priority setting is given a context, and the content of the response is highly interesting: the rejection of "big science" projects in favor of "small science" may be one of the first measures of the power of concentrated interest group pressure on public allocations, inevitably raising questions both about the sources of information of those who make decisions about science, and the effectiveness of the scientific and engineering community, writ large, to influence the science policy process.

Paradoxically, one must note the failure of the survey

respondents, on the one hand, to grasp the full measure of their political relationship to the wider society that supports them, and on the other, the allocation decisions by science policy makers, which indicate that concentrated special interests within the science and engineering community have succeeded in gaining political support and funding for projects not generally esteemed by the scientific and engineering community. Could there be a connection between political naivete and outcomes of allocation? Once again, public choice theory may help to elucidate the relationship.

When scientists and engineers indicate that they have a responsibility for improving the public understanding of basic research they must also recognize the stake they have in improving the understanding of their views among those who make decisions about science allocations.

The current discussion on education and human resources can be informed by three questions from the 1988 survey, the answers to which are supportive of initiatives to increase emphasis on science education and recruitment of individuals to careers in science and engineering. On issues relating to education, the respondents divided on the question of whether, in the face of static funding, a greater share should support students rather than research. One might have anticipated a greater weight on the research side, given the population from which the sample was drawn. Further, somewhat

unexpected support was shown for science education when nearly two-thirds of the respondents rejected the proposition that performing as both a teacher and a researcher hurts both functions. And, when asked whether they would recommend science as a career two-thirds said they would. An interesting feature of this response was that biological scientists and health scientists were the least supportive of this statement, raising once again the question of whether some special difficulties exist within that part of the scientific community.

Gender Considerations

Gender considerations have been elaborated in Section Three and need not be repeated here. A real suspicion has developed from examining the data that women scientists and engineers are less well rewarded than their male cohorts, which may account for the less wholehearted endorsement by women of a career in science or engineering. This message, while not strident, does not bode well for efforts to attract women to these professions; at the least it suggests that existing efforts to do this may require reinforcement to make the impact policy makers desire.

The gender aspect of attitude and opinion research requires more in-depth analysis than has been able to be performed for this overview. The age factor related to gender cohorts must be formally addressed to assess its influence on income; age is

unlikely to account for all the difference, but it surely accounts for some.

ENDNOTES

1. National Science Foundation, Science Resource Studies,"Employed Doctoral Scientists and Engineers by Field: 1977-1987," Selected Updated Charts and Tables for Science and Technology Resources Chart Book, Washington, D.C. 1988.

2. Jackson, C. Ian, A New Agenda For Science, Sigma Xi, New Haven, CT., 1986. This is a report of the findings of the 1986 Survey of Scientists and Engineers.

3. Sommer, Jack and Debbie Seltzer, Sketches of the American Scientist, Sigma Xi, New Haven, CT, 1988.

4. U.S. House of Representatives, Committee on Science and Technology, Chairman's Report, American Science and Science Policy Issues, GPO, Washington, D.C., 1986, pp. 190-196.

5. Data analytic support and graphics presentation for this project was provided by DLS Research Associates of Pittsburgh, Pennsylvania.

6. Wilkinson, R. Keith, National Science Foundation, Science Resource Studies, Science and Engineering Personnel: A National Overview, NSF 90-310, Washington, D.C., 1990, p. 6.

Exhibit 1

DISCIPLINARY AFFILIATION OF SIGMA XI SCIENTISTS AND ENGINEERS

Membership in Sigma Xi, when considered by field of science, as reported in the 1988 Survey of Scientists, approximates the "Employed Doctoral Scientists and Engineers by Field: 1977-1987" as shown in the National Science Foundation distribution, "Selected Updated Charts and Tables for Science and Technology Resources Chartbook. This seems reasonable because nearly four-fifths of the Sigma Xi members have either a Ph.D. or an MD, and nearly nine-tenths reported they are employed. The remainder reported they are retired. The 1988 Survey of Scientists recorded 3.4% "No Answer"; these are distributed proportionally across the field categories.

FIELD	SIGMA XI MEMBERSHIP		NSF CHARTBOOK*	DIF
	Survey	Actual		Survey/Chartbook
Physical Sciences	26.0%	26.8%	20.6%	+5.4%
Biological Sciences	25.1%	25.3	14.8%	+10.3%
Engineers	21.6%	21.3	16.2%	+5.4%
Social Scientists	7.6%	6.7	29.2%	-21.6%
Medical Sciences	7.3%	7.7	7.1%	+0.2%
Agricultural Sciences	7.0%	7.2	8.0%	-1.0%
Math & Computer Sciences	5.4%	5.0	8.4%	-3.0%

*Sums to >100%, probably due to rounding.

EXHIBIT 2

SAS 23:00 Tuesday June 5, 1990

Sigma Xi Field Code

P1	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	129	3.4	129	3.4
Biological	911	24.2	1040	27.7
Agricultural	255	6.8	1295	34.4
Engineering	784	20.9	2079	55.3
Health Science	265	7.0	2344	62.3
Math & Comp Sci	195	5.2	2539	67.5
Physical	945	25.1	3484	92.7
Social	276	7.3	3760	100.0

Employment Status

P22	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	460	12.2	460	12.2
Acad/Tenured	1235	32.8	1695	45.1
Acad/Nontenured	466	12.4	2161	57.5
Government	430	11.4	2591	68.9
Private	975	25.9	3566	94.8
Other	193	5.1	3759	100.0
Miscoded	1	0.0	3760	100.0

Sex

P5	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	45	1.2	45	1.2
Female	594	15.8	639	17.0
Male	3104	82.6	3743	99.5
Miscoded	17	0.5	3760	100.0

Age

P6	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	19	0.5	19	0.5
20-29	285	7.6	304	8.1
30-39	801	21.3	1105	29.4
40-49	933	24.8	2038	54.2
50-59	798	21.2	2836	75.4
60+	922	24.5	3758	99.9
Miscoded	2	0.1	3760	100.0

Science transcends national concerns

Q6	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	24	0.7	24	0.7
Emph. Disagree	83	2.5	107	3.2
Disagree	340	10.2	447	13.4
No Opinion	247	7.4	694	20.8
Agree	1408	42.3	2102	63.1
Emph. Agree	1230	36.9	3332	100.0

Competition depends on basic research

Q7	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	16	0.5	16	0.5
Emph. Disagree	50	1.5	66	2.0
Disagree	323	9.7	389	11.7
No Opinion	394	11.8	783	23.5
Agree	1410	42.3	2193	65.8
Emph. Agree	1139	34.2	3332	100.0

Most important current issues

Q8	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	137	4.1	137	4.1
Lack of Pub Und	1290	38.7	1427	42.8
Interrupt Fund	681	20.4	2108	63.3
Overpoliticizati	750	22.5	2858	85.8
No Interdiscipli	329	9.9	3187	95.6
Other	145	4.4	3332	100.0

Congress should provide research agenda

Q21	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	16	0.5	16	0.5
Emph. Disagree	851	25.5	867	26.0
Disagree	1147	34.4	2014	60.4
No Opinion	456	13.7	2470	74.1
Agree	721	21.6	3191	95.8
Emph. Agree	141	4.2	3332	100.0

Congress shouldn't target projects

Q22	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	22	0.7	22	0.7
Emph. Disagree	56	1.7	78	2.3
Disagree	506	15.2	584	17.5
No Opinion	423	12.7	1007	30.2
Agree	1413	42.4	2420	72.6
Emph. Agree	912	27.4	3332	100.0

Pork barrel wrong allocation for science

Q23	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	28	0.8	28	0.8
Emph. Disagree	54	1.6	82	2.5
Disagree	287	8.6	369	11.1
No Opinion	388	11.6	757	22.7
Agree	1315	39.5	2072	62.2
Emph. Agree	1260	37.8	3332	100.0

Dept. of Science: pros outweigh cons

Q24	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	60	1.8	60	1.8
Emph. Disagree	276	8.3	336	10.1
Disagree	589	17.7	925	27.8
No Opinion	980	29.4	1905	57.2
Agree	1075	32.3	2980	89.4
Emph. Agree	352	10.6	3332	100.0

Value of basic research unpredictable

Q29	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	38	1.1	38	1.1
Emph. Disagree	18	0.5	56	1.7
Disagree	76	2.3	132	4.0
No Opinion	125	3.8	257	7.7
Agree	1332	40.0	1589	47.7
Emph. Agree	1743	52.3	3332	100.0

Cannot guarantee results in advance

Q30	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	39	1.2	39	1.2
Emph. Disagree	17	0.5	56	1.7
Disagree	120	3.6	176	5.3
No Opinion	99	3.0	275	8.3
Agree	1205	36.2	1480	44.4
Emph. Agree	1852	55.6	3332	100.0

Govt should fund only applied research

Q31	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	60	1.8	60	1.8
Emph. Disagree	1010	30.3	1070	32.1
Disagree	881	26.4	1951	58.6
No Opinion	395	11.9	2346	70.4
Agree	726	21.8	3072	92.2
Emph. Agree	260	7.8	3332	100.0

Applied research funded privately

Q32	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	40	1.2	40	1.2
Emph. Disagree	766	23.0	806	24.2
Disagree	1374	41.2	2180	65.4
No Opinion	419	12.6	2599	78.0
Agree	576	17.3	3175	95.3
Emph. Agree	156	4.7	3331	100.0
Miscoded	1	0.0	3332	100.0

Public understanding my responsibility

Q33	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	32	1.0	32	1.0
Emph. Disagree	23	0.7	55	1.7
Disagree	70	2.1	125	3.8
No Opinion	224	6.7	349	10.5
Agree	1495	44.9	1844	55.3
Emph. Agree	1487	44.6	3331	100.0
Miscoded	1	0.0	3332	100.0

Education over research

Q36	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	42	1.3	42	1.3
Emph. Disagree	231	6.9	273	8.2
Disagree	985	29.6	1258	37.8
No Opinion	951	28.5	2209	66.3
Agree	905	27.2	3114	93.5
Emph. Agree	216	6.5	3330	99.9
Miscoded	2	0.1	3332	100.0

Dual role detrimental

Q37	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	32	1.0	32	1.0
Emph. Disagree	815	24.5	847	25.4
Disagree	1252	37.6	2099	63.0
No Opinion	330	9.9	2429	72.9
Agree	607	18.2	3036	91.1
Emph. Agree	296	8.9	3332	100.0

Recommend science as a career

Q41	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	56	1.7	56	1.7
Emph. Disagree	68	2.0	124	3.7
Disagree	386	11.6	510	15.3
No Opinion	590	17.7	1100	33.0
Agree	1582	47.5	2682	80.5
Emph. Agree	650	19.5	3332	100.0

No Answer	362	9.6	362	9.6
Untargeted IIAs	623	16.6	985	26.2
AIDS	480	12.8	1465	39.0
Bio/Geosphere	503	13.4	1968	52.3
ERCs/STCs	415	11.0	2383	63.4
Human Genome	210	5.6	2593	69.0
Space Station	323	8.6	2916	77.6
SDI	161	4.3	3077	81.8
Superconductors	432	11.5	3509	93.3
SSC	99	2.6	3608	96.0
Other	138	3.7	3746	99.6
Miscoded	14	0.4	3760	100.0

Q26	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	1852	24.6	1852	24.6
None/it works	442	5.9	2294	30.5
Nonexperts	422	5.6	2716	36.1
Cursory Reviews	520	6.9	3236	43.0
Conflicting	266	3.5	3502	46.6
Cronyism	1816	24.1	5318	70.7
Inconsistent	273	3.6	5591	74.3
Unoriginal	1528	20.3	7119	94.7
Ideas 'leak'	308	4.1	7427	98.8
Other	93	1.2	7520	100.0

Concerns with peer review: I

Q26A	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	886	23.6	886	23.6
None/it works	375	10.0	1261	33.5
Nonexperts	188	5.0	1449	38.5
Cursory Reviews	208	5.5	1657	44.1
Conflicting	101	2.7	1758	46.8
Cronyism	1184	31.5	2942	78.2
Inconsistent	91	2.4	3033	80.7
Unoriginal	613	16.3	3646	97.0
Ideas 'leak'	77	2.0	3723	99.0
Other	37	1.0	3760	100.0

Concerns with peer review: II

Q26B	Frequency	Percent	Cumulative Frequency	Cumulative Percent
No Answer	966	25.7	966	25.7
None/it works	67	1.8	1033	27.5
Nonexperts	234	6.2	1267	33.7
Cursory Reviews	312	8.3	1579	42.0
Conflicting	165	4.4	1744	46.4
Cronyism	632	16.8	2376	63.2
Inconsistent	182	4.8	2558	68.0
Unoriginal	915	24.3	3473	92.4
Ideas 'leak'	231	6.1	3704	98.5
Other	56	1.5	3760	100.0

Preliminaries

Before you proceed to answer the questionnaire, please take time to familiarize yourself with the following definitions of what your answers will mean to the investigators.

(4) Agree emphatically - this means that you strongly support the statement or argument presented in the question based on personal knowledge and sifting of much evidence. Your inferences are drawn, you believe, with regard to the standards of correct scientific procedure and rules of evidence.

(3) Agree in substance - this response means that, although you know of specific cases where the thrust of the statement or argument might not apply, in general, you agree with its substance. You would like to have better evidence in the future, but for now, you are inclined to accept the statement.

(2) Disagree in substance - this response means that, although you know of specific cases where the thrust of the statement or argument might apply, in general, you cannot accept its truth. You would like to have better evidence in the future, but for now, you must disagree.

(1) Disagree emphatically - this means that you strongly oppose the substance of the statement or argument presented based on personal expertise and a sifting of the evidence. This response is the antithesis of response (4)

(0) Not certain - this response means that, although you might have an opinion on the matters expressed in the statement or argument, you recognize that you do not have enough information to justify taking a definite position.

Survey Questions

(Please circle the response that most closely resembles your view as detailed by the above list of definitions.)

(01) The word science is often invoked as if it meant a particular "thing" comprised of scientists, public and private laboratories, publications, and government agencies. For me, however, "science" connotes a process or procedure for making inquiries about our world and for evaluating the hypotheses these inquiries generate.

4 3 2 1 0

(02) Much governmentally funded research is "discipline specific," with different agencies funding small pools of talent working on narrow research agendas. More interdisciplinary research should be funded because many of the most significant scientific problems cannot be accommodated within arbitrary disciplinary structures.

4 3 2 1 0

(03) Current science research funds are often "targeted" for given problems, such as the National Cancer Institute or SDI. Government creation of such large research agendas is based on the belief by the public and their elected representatives that scientists, given enough money, can "deliver the goods." I believe this idea misconstrues the nature of scientific endeavour and scientific progress.

4 3 2 1 0

(04) Scientists engaged in nationally targeted research agendas are under pressure to produce results. Such pressure can, and does, lead to the release of selective experimental results that prematurely raise the public's expectations of eventual success.

4 3 2 1 0

(05) Every funding agency empowered to award government research monies is dominated by a particular methodological paradigm by which it judges what is and what is not acceptable science in the agency's area of specialization. The chance of any non-mainstream proposals being funded is very small.

4 3 2 1 0

(06) I spend almost as much time preparing the materials with which to try to receive a governmentally funded research grant as I end up spending on the research itself. The paperwork is endless, the compliance procedures onerous.

4 3 2 1 0

(07) Procurement procedure for grants to do governmentally sponsored research depends on "who you know." Many requests seem to be funded primarily because the researchers are already known to and supported by the granting organizations.

4 3 2 1 0

(08) Many individuals, institutions, and interest groups compete for government research funds. I believe that research monies and research trends are tied too closely to prevailing political priorities and fashions.

4 3 2 1 0

(09) Democratic government is responsible to the voters on questions of dispensation of tax monies, and it has a large role in whatever expenditure process it initiates. I believe the proper role for government with regard to the funding of science is to define what should be investigated, thereby providing scientists with a "research agenda," and to require delivery of research output, on the premise that a contractual relationship exists between scientists and society.

4 3 2 1 0

(10) Government should provide national research facilities and instruments for the achievement of ongoing public research agendas on the premise that some research cannot be accomplished by universities and/or the private sector.

4 3 2 1

(11) Government should fund research that qualified scientists think is important, then it should pursue a policy of "hands off," on the premise that only scientists can give proper direction to scientific inquiry.

4 3 2 1 0

(12) Government should monitor and assure the quality of ongoing and completed research by a process of peer review to protect the public's tax monies, health, and safety.

4 3 2 1 0

(13) The systems required to evaluate research and to guarantee its cost-effectiveness are in place, sufficient, and operating effectively.

4 3 2 1 0

(14) Academic research support has become yet another 'entitlement program. The monies are spent each year regardless of the worthiness of projects submitted for funding. The public then hears horror stories about the waste, and the relations between the public and science suffer.

4 3 2 1 0

(15) It is unfair that research partially or wholly funded with tax monies should result in private patents to individuals.

4 3 2 1 0

(16) The system of checks and balances within the democratic framework is generally sufficient to insure that government funding of research will remain closely related to the general wishes of society rather than be used primarily for partisan political ends.

4 3 2 1 0

(17) This system will also be sufficient to insure that government funded research will not result in the establishment of scientific orthodoxies.

4 3 2 1

(18) During periods of retrenchment of Federal support of research a desirable policy is to distribute the cuts across the board on a flat percentage basis, thereby to spread the pain evenly.

4 3 2 1 0

(19) Cuts in Federal support for research should be directed primarily at defense related science and technology.

4 3 2 1 0

SIGMA XI
OPINION SURVEY OF SCIENTISTS
General Information
(Please circle appropriate response(s).)

A. My three digit Sigma Xi field code is: ___ ___ ___

B. My age is: (1) 20-29 (2) 30-39 (3) 40-49 (4) 50-59 (5) 60 over

C. My highest attained degree is: (1) Bachelor's (2) Master's (3) Ph.D.

D. Status: (1) Retired (2) Not retired (3) Retired/still active in science

E. My primary employment is(was): (1) Academe/tenured (2) Academe/untenured (3) Government (4) Private Sector (5) Other

F. My primary professional experience has been in: (1) USA (2) Canada
(Please respond to this survey in the context of the country indicated)

G. Annual income in 'ooo's: (1) Below $25 (2) $25-34 (3) $35-44 (4) $45+

H. Do you have significant earnings from activities outside your primary employment? (1) Yes (2) No

I. Have you worked for more than three months in a research environment outside North America? (1) Yes (2) No

J. My research related travel usually takes me to:

(1) USA/Canada (2) Western Europe (3) USSR/Eastern Europe (4) Asia (5) Latin America/Caribbean (6) Elsewhere (7) Not applicable

K. The language I use in my work most often besides English is:

(1) German (2) French (3) Russian (4) Other (5) None Regularly

L. I have been a principal investigator on a federally funded research grant: (1) Yes (2) No

M. I have worked on a federally funded research grant as other than the principal investigator: (1) Yes (2) No

N. I have applied for a federal research grant but as yet I have not received one. (1) Yes (2) No

O. I have received significant research funding from a private foundation. (1) Yes (2) No

P. In general, I would describe my politics as:

(1) strong left (2) moderate liberal (3) center
(4) moderate conservative (5) strong right (6) libertarian (7) other

(20) Our country maintains what might be aptly termed an "open" process for citizen participation in technology decision making. The relationship between the scientific community and laypeople, though usually quite good, can become strained when scientists are perceived as helping to develop technologies that the average voter finds threatening. Examples might be nuclear weapons systems and power, genetic engineering, toxic pollutants, etc.;

I think that the development and implementation of potentially dangerous technology should depend, primarily, on citizen input through voting processes:

4 3 2 1 0

(21) I think that the development and implementation of potentially dangerous technology should be decided, primarily, within the scientific community itself through self-regulation:

4 3 2 1 0

(22) I think that the development and implementation of potentially dangerous technology should be decided, primarily, within the specific agencies that commission and develop the technologies and/or oversee its implementation:

4 3 2 1 0

(23) Technologies are often lobbied for, and against, by highly visible scientists and "scientist groups" that receive wide and continuing media coverage. To the layperson, it seems that scientific "experts" contradict each other as to the facts of completed research and implications of implementing new technologies.

I believe that these scientists and groups are more political than scientific when they speak on these issues:

4 3 2 1 0

(24) In my view, scientists disagree on policy issues because of reasonable differences in interpreting evidence:

4 3 2 1 0

(25) There is a growing tendency for scientists to allow their political views to interfere with their objective evaluation of scientific evidence:

4 3 2 1 0

(26) There is a growing tendency for scientists to sensationalize evidence in order to receive increased public exposure and/or to generate more income for themselves:

4 3 2 1 0

(27) Although international cooperation in basic science and free exchange of findings has been a tradition in the scientific community we must now be concerned that this handicaps the industrial competitiveness of our country.

4 3 2 1 0

(28) There are fundamental problems with the adequacy of the scientific physical plant and instrumentation necessary to carry out work in my field at my research facility.

4 3 2 1 0

(29) Many colleges and universities do not have state-of-the-art scientific equipment. Those without such equipment are denied research funds even though the researchers are competent, their designs valid, and the research does not require state-of-the-art equipment.

4 3 2 1 0

(30) Most of the really interesting research questions today require state-of-the-art scientific equipment.

4 3 2 1 0

(31) A continued supply of high quality scientists and engineers, with supply roughly equalling demand, is necessary for the maintenance and progress of our highly sophisticated and technological society.

The correct numbers of scientists and engineers should be provided by the market, through the mechanism of supply and demand.

4 3 2 1 0

(32) The correct numbers of scientists and engineers should be influenced, primarily, by the academic community since it is closest to the issue, and is able to counsel, persuade, and fund students.

4 3 2 1 0

(33) The correct numbers of scientists and engineers should be insured by government action and targeted funding.

4 3 2 1 0

(34) I believe there should be a national cabinet level Department of Science.

4 3 2 1 0

We wish to thank you for taking the time to respond to this survey. One final important question remains: Your personal view of what are the most critical issues facing science today. Please reflect on the following issues and choose the <u>two (2)</u> most important.

(35) I believe the two most important issues facing the scientific community today are: (Circle those two)

(1) Interruptions in funding for research
(2) Disappearing fields of inquiry
(3) Lack of interdisciplinary training
(4) Lack of public understanding of science's place
(5) Overreliance on science to provide answers and find solutions
(6) Over commercialization of research
(7) Over politicization of research
(8) Fraud and plagiarism in research
(9) Other

(36) Please add any comments about the topics covered in the questionnaire or about the research environment and the future of science in general. These comments will be detached from the questionnaire and analyzed separately. If you wish to identify yourself (name and address or membership number), please do so; otherwise your entire response will be anonymous. Use additional sheets if necessary.